

The Pad Chambers (PC)

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Lund Univ.

On behalf of the groups at

BNL

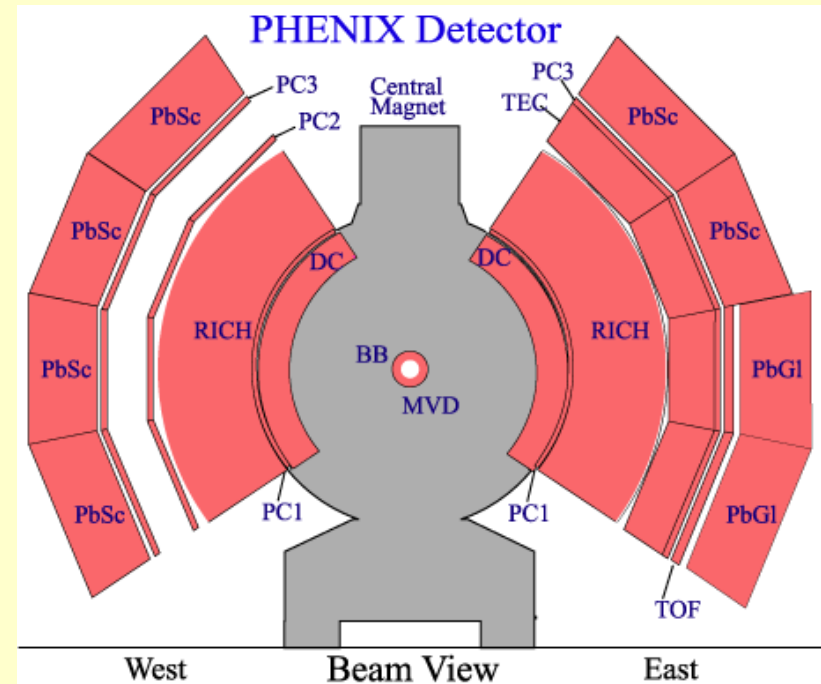
Lund

ORNL

SunySB-C

Vanderbilt U

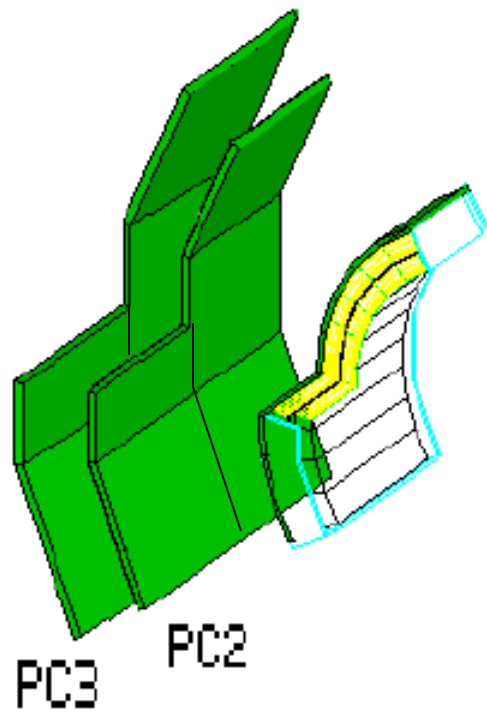
Weizmann Inst.



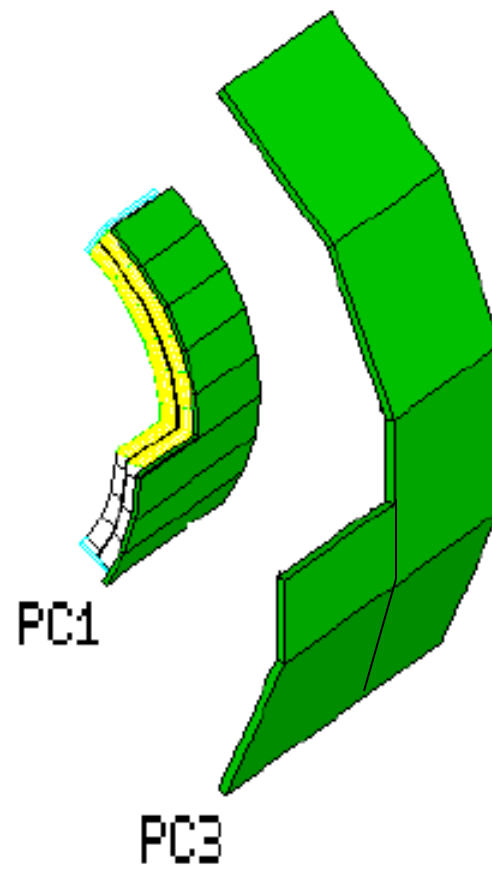
PCs role in PHENIX

- Straight line tracking by space points
- Z-coord from PC1
- Pattern in 3D
- Verify tracks thru arm for safe part. ID.
- Charged particle veto in front of EmCal
- Entrance/exit points (RICH, EmCal) for Lvl2 trigger

west



East



Problem: tracking at high Multiplicity. Design $dN/d\eta=2000$
Double Hijing (gives 700 in central arms).

Basic Instincts:

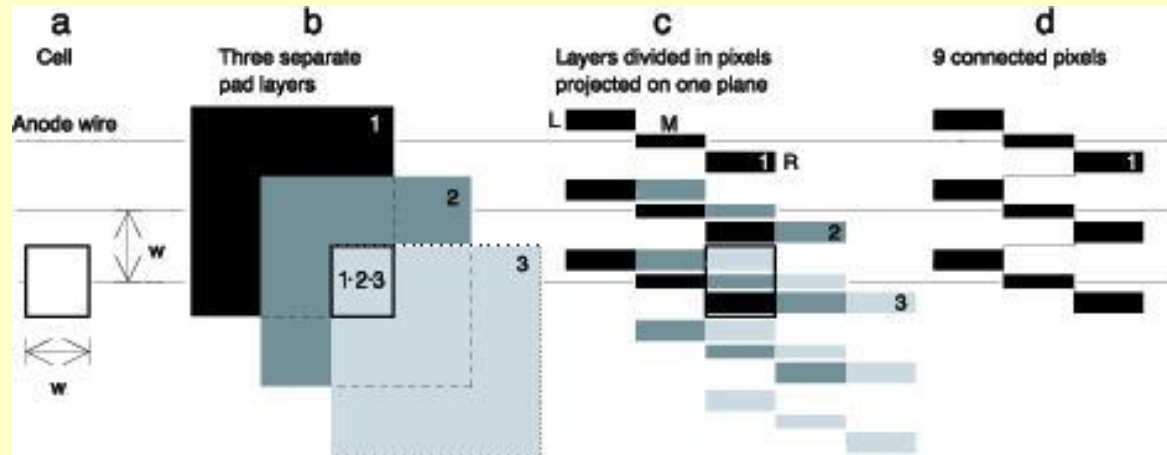
- Resolve in 3D by space points
- If 100% eff
- pos resolution and 2-track separation much better than average track dist
- then 3 points on a straight line makes it

Basic idea:

- make a lot of small readout cells with low resolution readout instead of the normal in HEP, large cell with high resolution readout to get the pos. resolution.
- Solve the problem of putting FEE in the fiducial volume

What you gain:

- Low input capacitance
- Low rate, simpler analog design
- Low power
- Simple A-D conversion
- Small data volume
- 1-2\$ per ch. instead of \$50

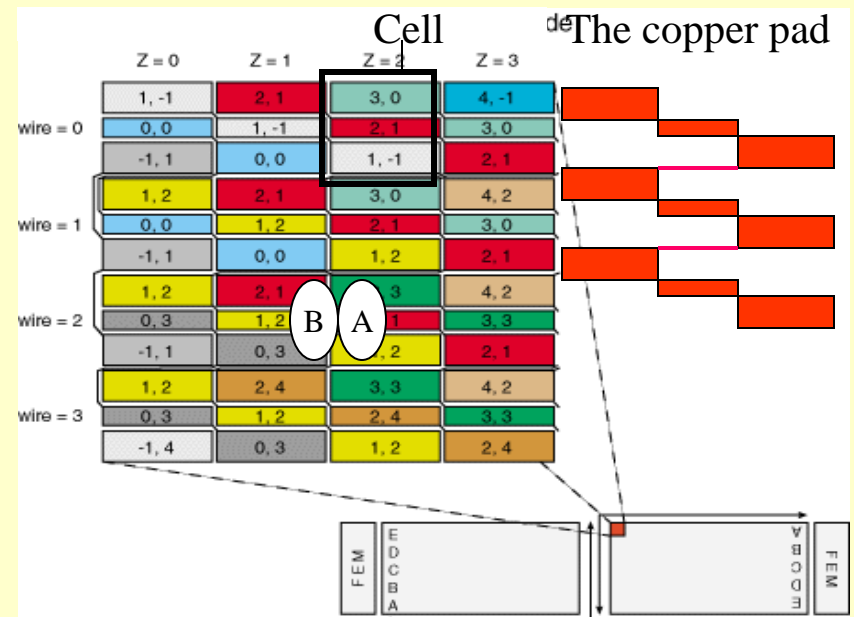
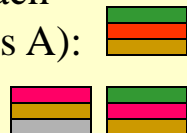


Pixel readout:

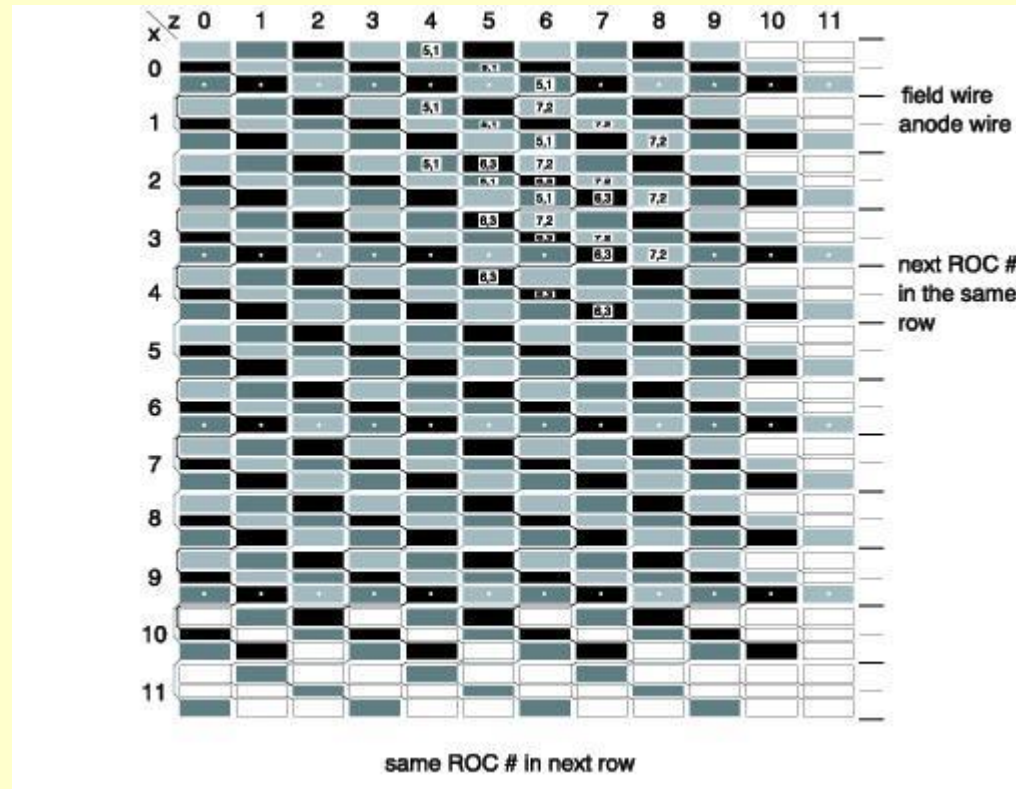
- 3 adjacent channels (pads) fire for each hit
- Each cell has unique triplet of channels
- 14400 cells per m^2 on PC1.
- Same $d\Omega$ in PC1,2,3 (angular resolution).
- Reconstruct to center of cell or between 2 cells
- Saves factor 3 compared to readout of cells.
- Occupancy $\sim 1\%$ in central AuAu

Example:

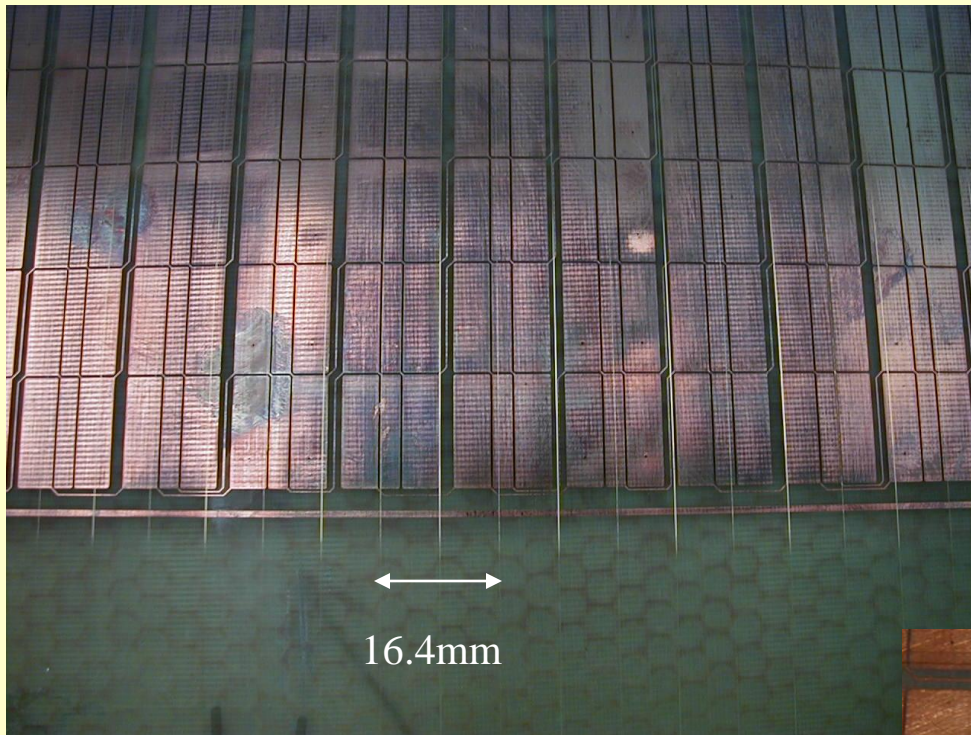
- Electrons drift to wire \rightarrow avalanche signal
- Charge shared between pads in the cell
- Pad areas chosen to get 1/3 charge each
- If hit is central in cell along wire (pos A):
- If hit is between 2 cells (pos B):



Whatabout the edges?



Cut away pixels that have no neighbour. Works as well at the edges as in the interior. We have edges between all FEMs So, everything needed to reconstruct contained in One FEM-DCM chain. Great for LVL2.



The etched copper cathode
PC3 size.

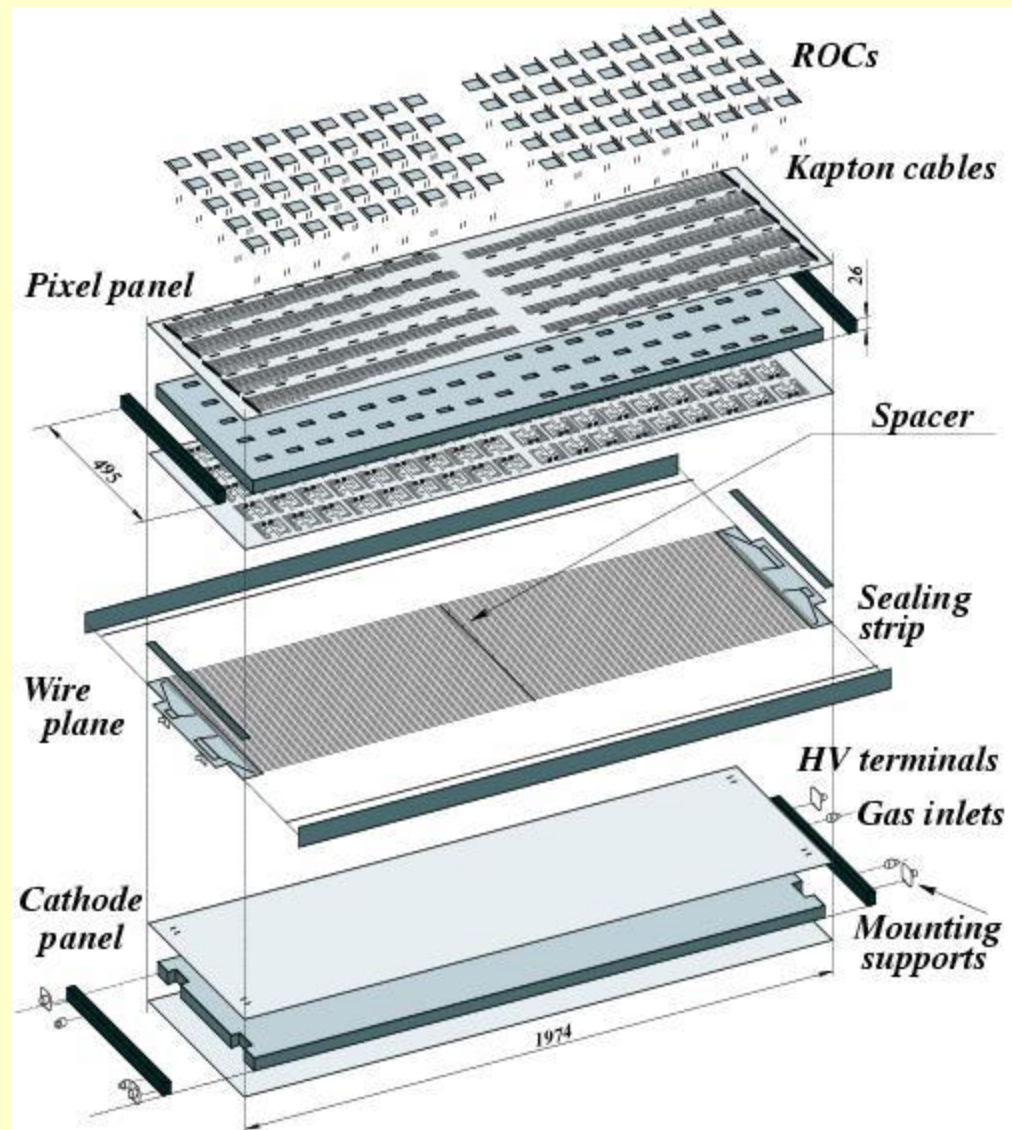


Large area 1m*2m PC3 board
with very fine traces and gaps.

Hit resolution limit of CAD
programs.
Difficult to make.



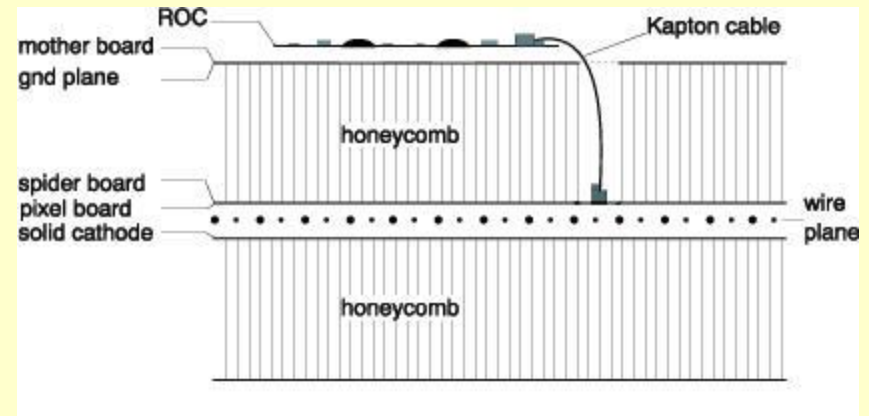
PC1, mech. Comp.
from WI



Weight 7kg

Chamber construction:

- MWPC
- PC1 No frame in fiducial volume.
- PC2/3 Thin Frame for gas seal.
- Wire tension held by Honeycomb sandwich
- Ar/Ethane 50/50 flammable gas



chamber	Wire dist (mm)	gas gap (mm)	Pixel length (mm)	Rad. Thickn.
PC1	8.4	6	8.4	1.2%
PC2	13.6	10	14.2	2.4%
PC3	16.0	12	16.7	2.4%

Geometry within a module

A module corresponds to a half chamber, read out by one FEM

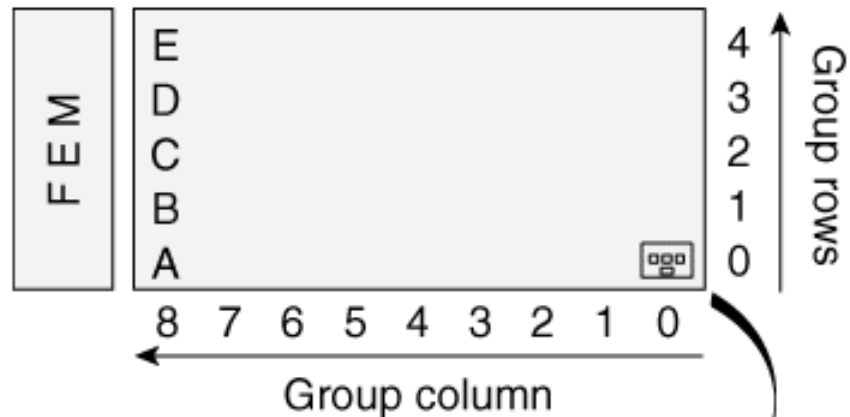
Geometry the same everywhere.

Only size is different.

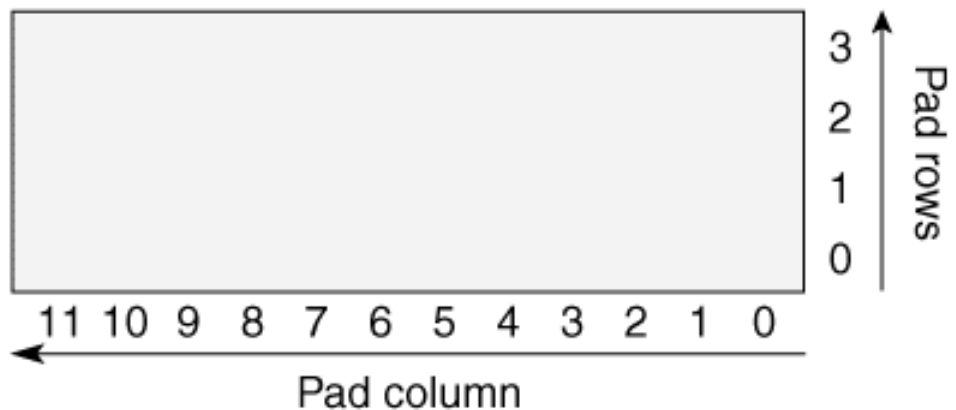
Same software all over PCs for local coordinates

Everything to same FEM

FEM + Chamber module, from motherboard side



Pad group



PC1, East arm [1] as viewed from IP

FEM id	North side [1]	South side [0]
7	Sub sector 7	
6	Sub sector 6	
5	Sub sector 5	
4	Sub sector 4	
3	Sub sector 3	
2	Sub sector 2	
1	Sub sector 1	
0	Sub sector 0	

PC3, East arm [1] as viewed from IP

FEM id	FEM id	North side [1]	South side [1]	FEM id
7	7			7
6	6	Sector 3		6
5	5			5
4	4	Sector 2		4
3	3			3
2	2	Sector 1		2
1	1			1
0	0	Sector 0		0

Length scale on PC3 is twice that of PC1. Double distance
Means same angular resolution

Chamber assembly in 820

A little prayer
can not harm

PC2/3 panels
from VU
Wire stringing
at BNL



Wire support

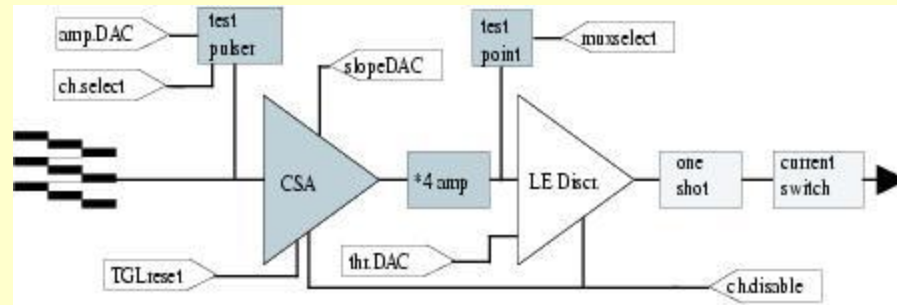
Frame with O-ring

No, the canadian says.
We're gonna make it
without supernatural help

Readout electronics

TGLD ASIC:

- 16ch amp/discr
- 2fC thresh, min
- Testpulsing of ch.
- Remote serial CTRL

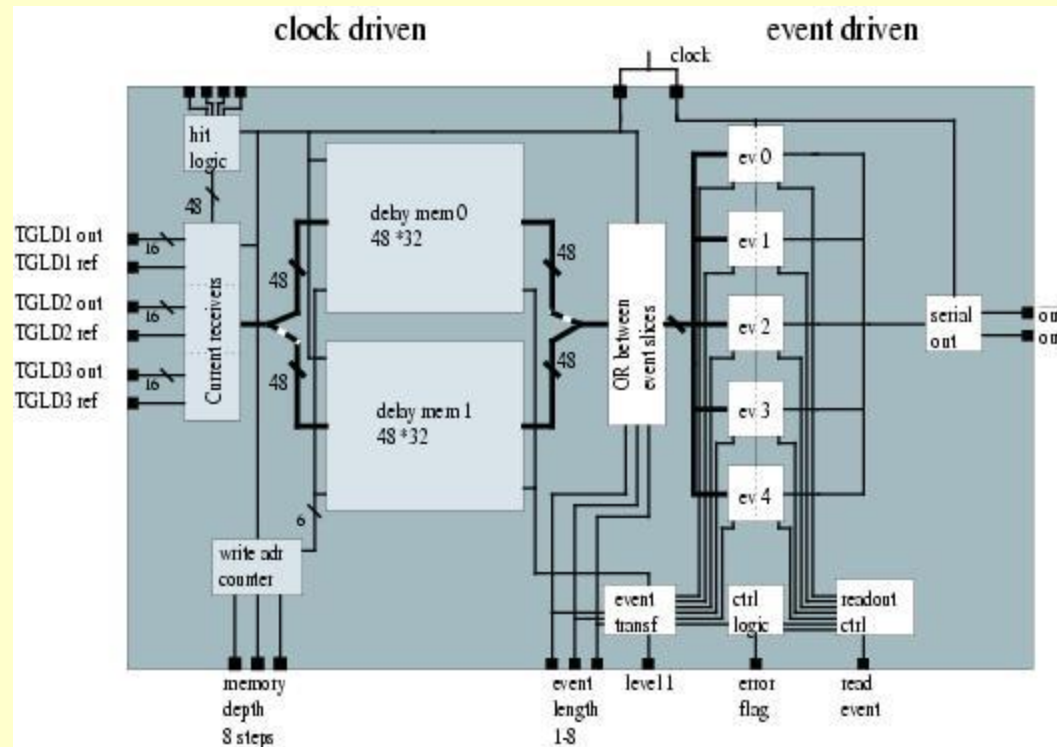


One channel TGLD

ORNL design
Lund testing

DMU ASIC:

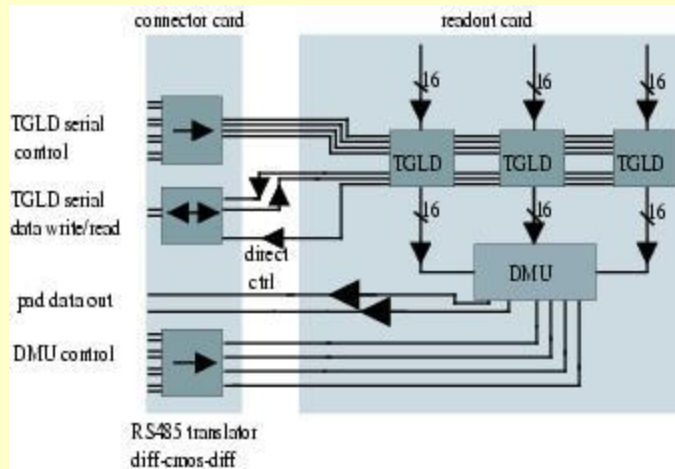
- 48ch delay mem.
- 5 event mem.
- Parallel in serial out
- Serves 3 TGLD



48 channels in one DMU

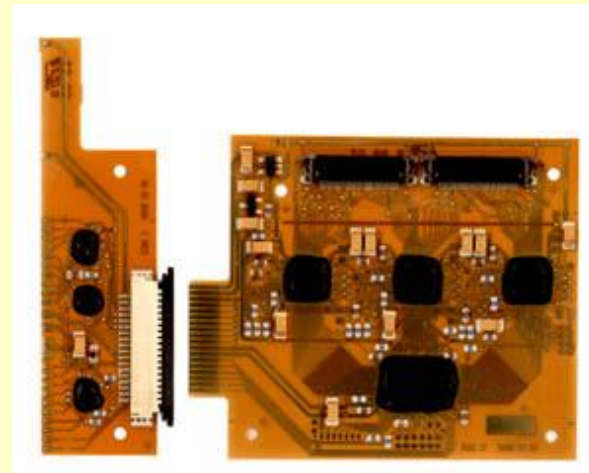
Lund
+SiCon

Readout electronics



Connector card soldered to
Motherboard (top skin of pixel
honeycomb sandwich.)

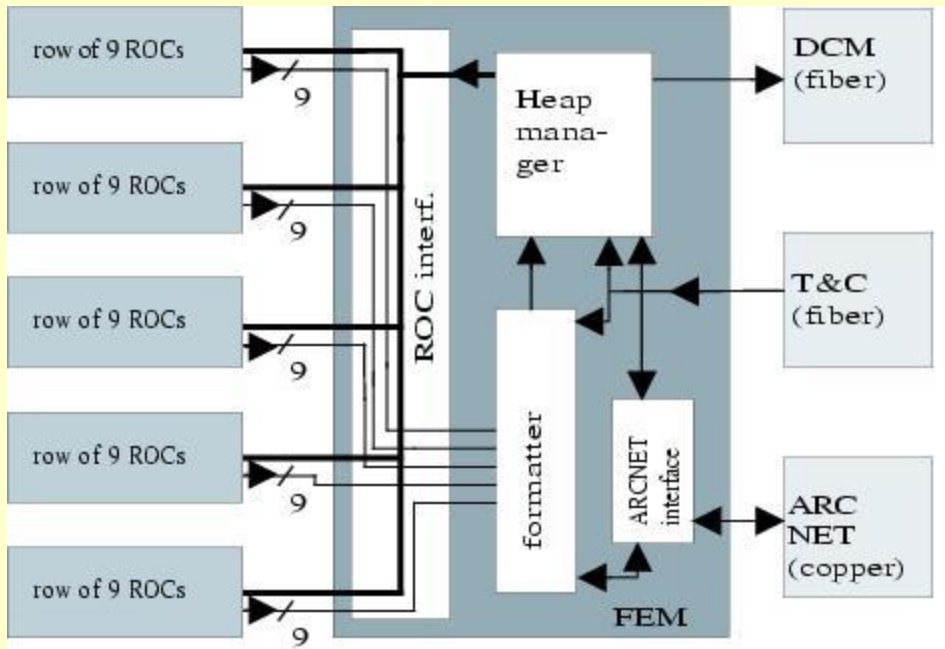
The ROCs



Lund
+Xicon

A ROC/conn card:

- 3 TGLD chips
- 1 DMU chip
- 48 channels
- Diff-CMOS transl.
- Chip on Board assembly
- Conductive glue for components
- Local voltage regulation.
- 0.2% of χ_0 on PC1.
- ~\$75 per ROC incr. Cost
- 5000 made, 3600 used

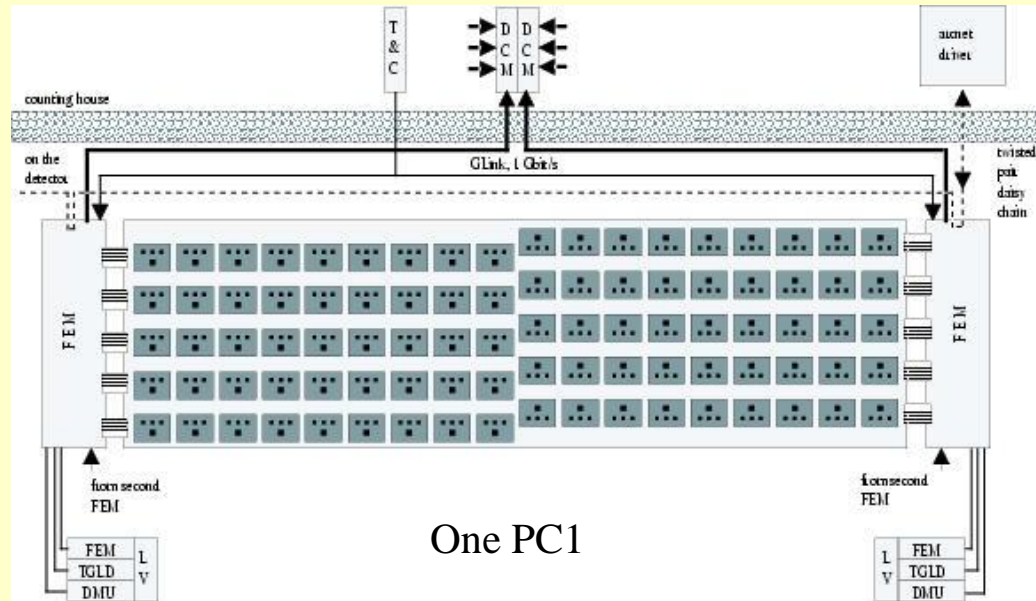


The FEM:

- Serial control of TGLD
- PWR distribution to ROCs
- Data readout from DMUs
- Data formatting
- Data transfer by Glink 800Mbit/s
- Timing and mode control

ORNL + SB

Readout architecture



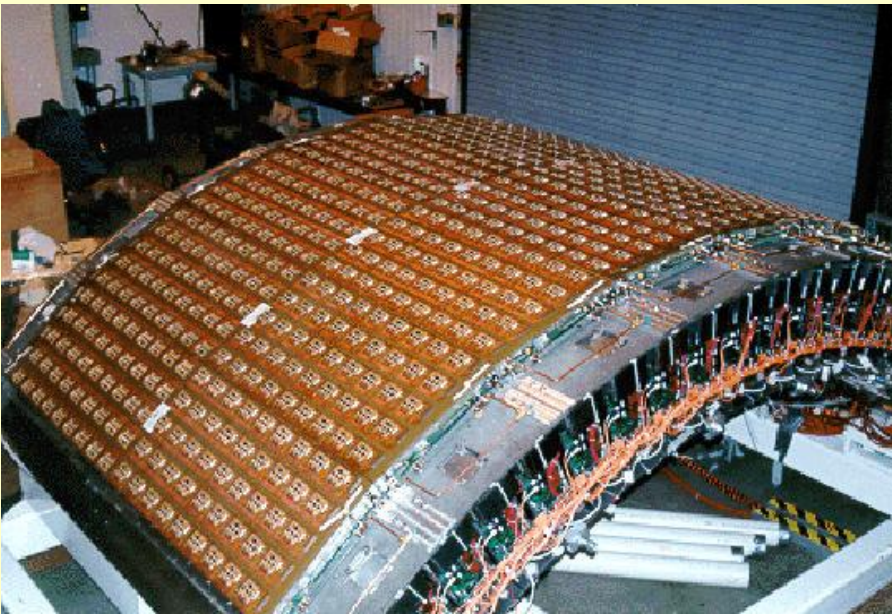
Handling an event.

- 48+3+1 ticks (all ROCs to FEM)
- Formats to 108, 20 bit words
- Each word is 20 pad across
- Word number Z-coordinate
- Bit number is x-coordinate
- Bitwise .AND. word i-1,i,i+2 for cell
- Zero supp, skip 20 bit words if zero
- Average 4-5 word per hit.

Readout of one chamber:

- 2 FEMs (PC2,3 side by side)
- Multiplexed readout (same side)
- Identical readout for all FEMs
- 3 fibers and 1 twist pair per chamber

PC1 on DCh



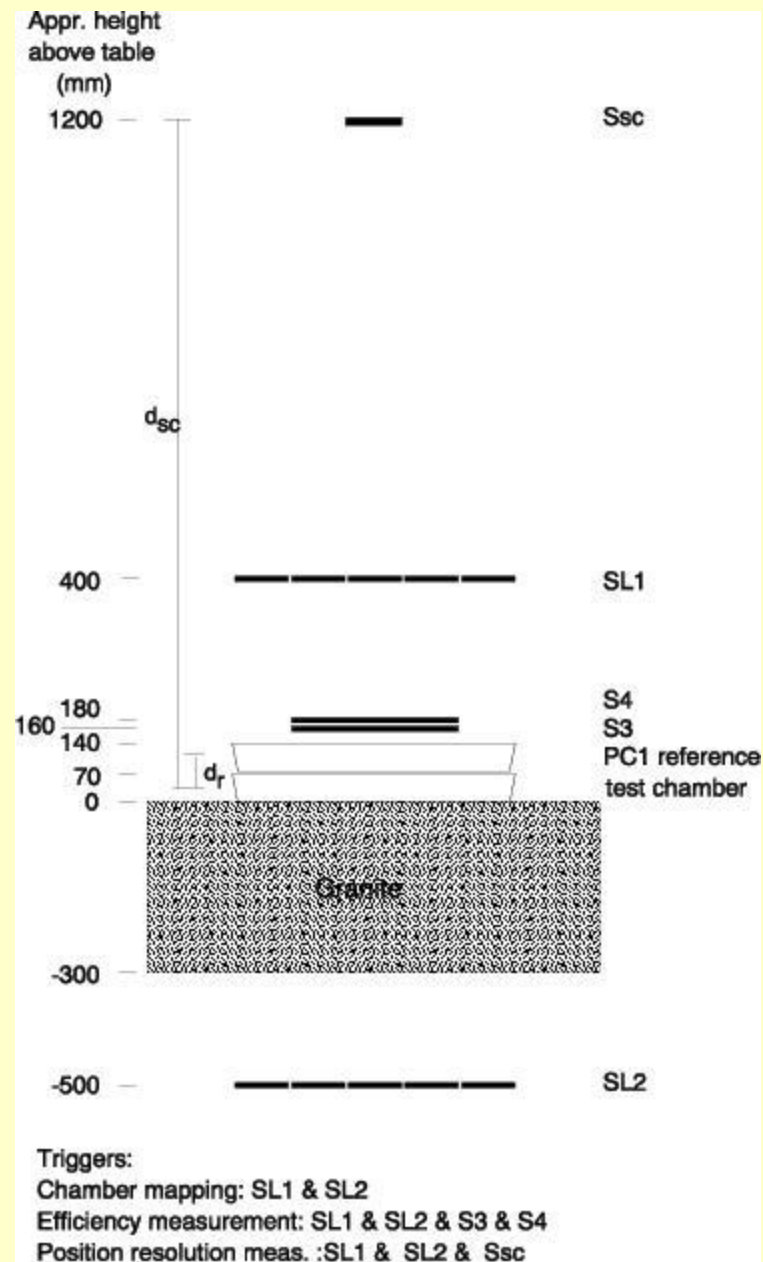
- Five planes: East PC1,3 & WEST PC1,2,3
- $\Delta\phi=90^\circ$, $|\eta|=0.35$
- 80m^2 MWPC, pixel cathode readout,
- 172800k readout channels,
- $1.2\% \chi_0$ (PC1) with electronics on back

Performance: cosmics

The cosmic test stand.

4 fold coinc for efficiency

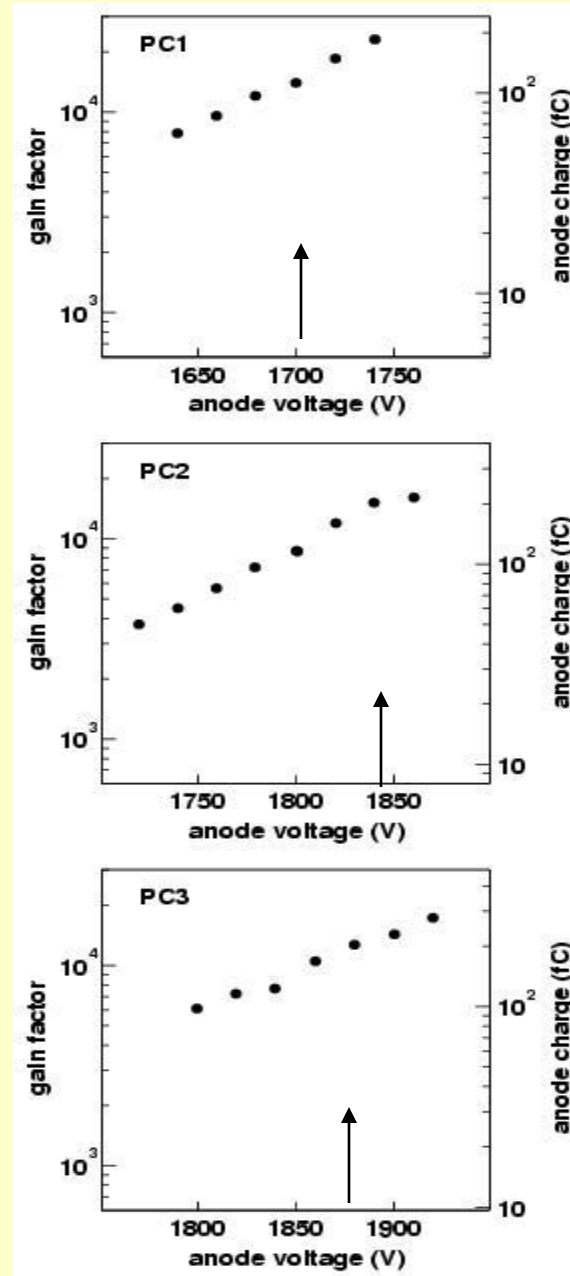
Large area tested, not only sweetspot



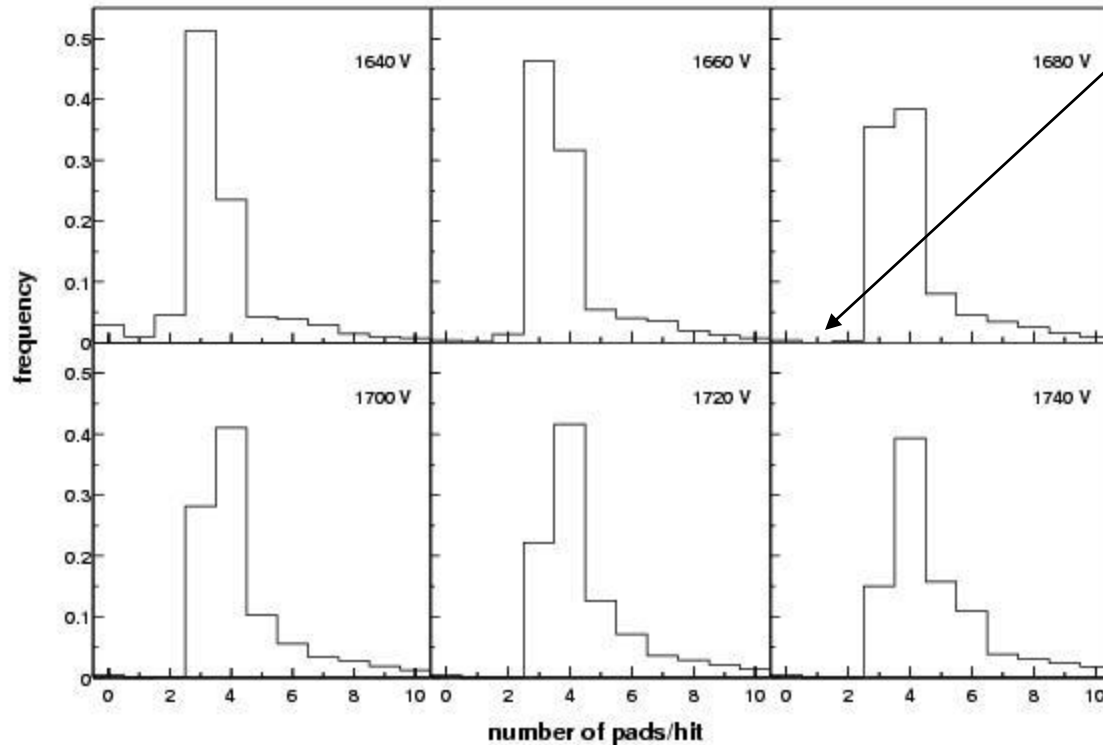
Performance: cosmics

Gain curves

Running at $1-2 \times 10^4$



Performance: cosmics

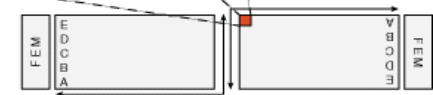


Always 3 or more
when full efficiency

Pad multiplicity distribution per hit

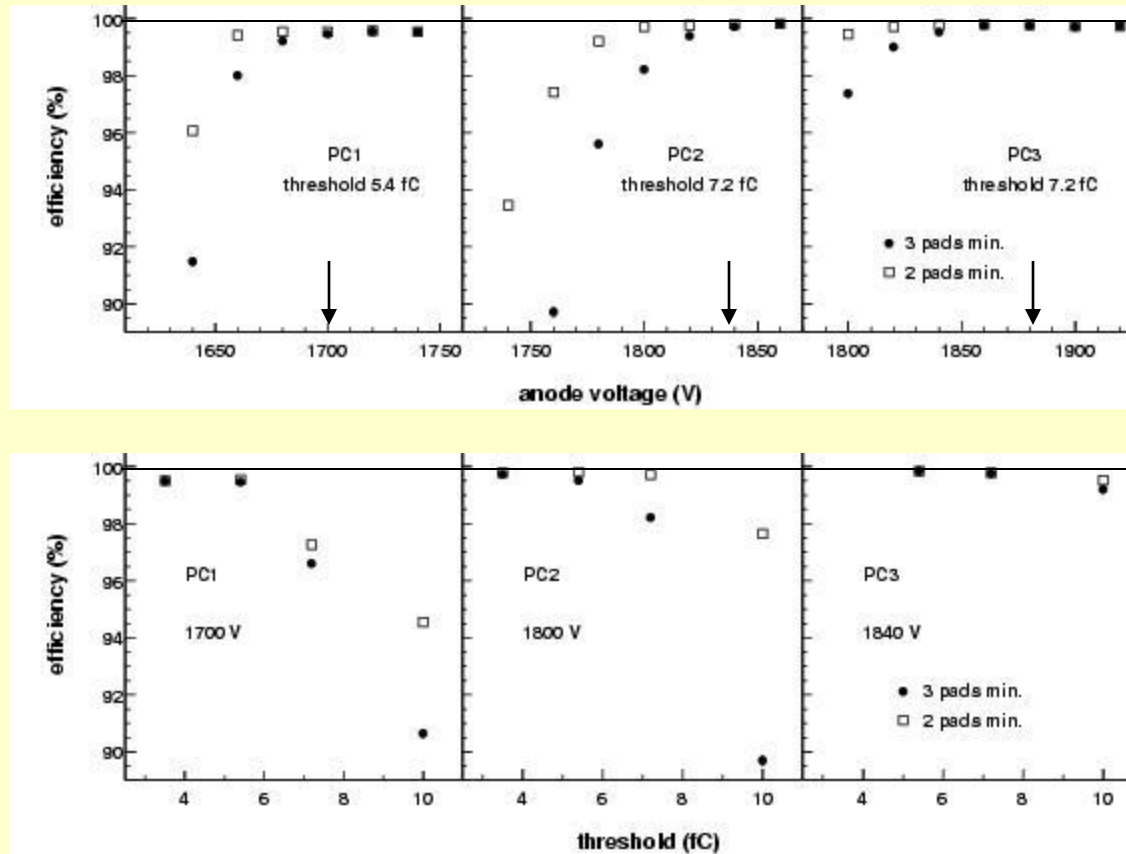
Pad Numbering scheme, from motherboard side

	Z = 0	Z = 1	Z = 2	Z = 3
wire = 0	1, -1 0, 0 -1, 1	2, 1 1, -1 0, 0	3, 0 2, 1 1, -1	4, -1 3, 0 2, 1
wire = 1	1, 2 0, 0 -1, 1	2, 1 1, 2 0, 0	3, 0 2, 1 1, 2	4, 2 3, 0 2, 1
wire = 2	1, 2 0, 3 -1, 1	2, 1 1, 2 0, 3	3, 3 2, 1 1, 2	4, 2 3, 3 2, 1
wire = 3	1, 2 0, 3 -1, 4	2, 4 1, 2 0, 3	3, 3 2, 4 1, 2	4, 2 3, 3 2, 4

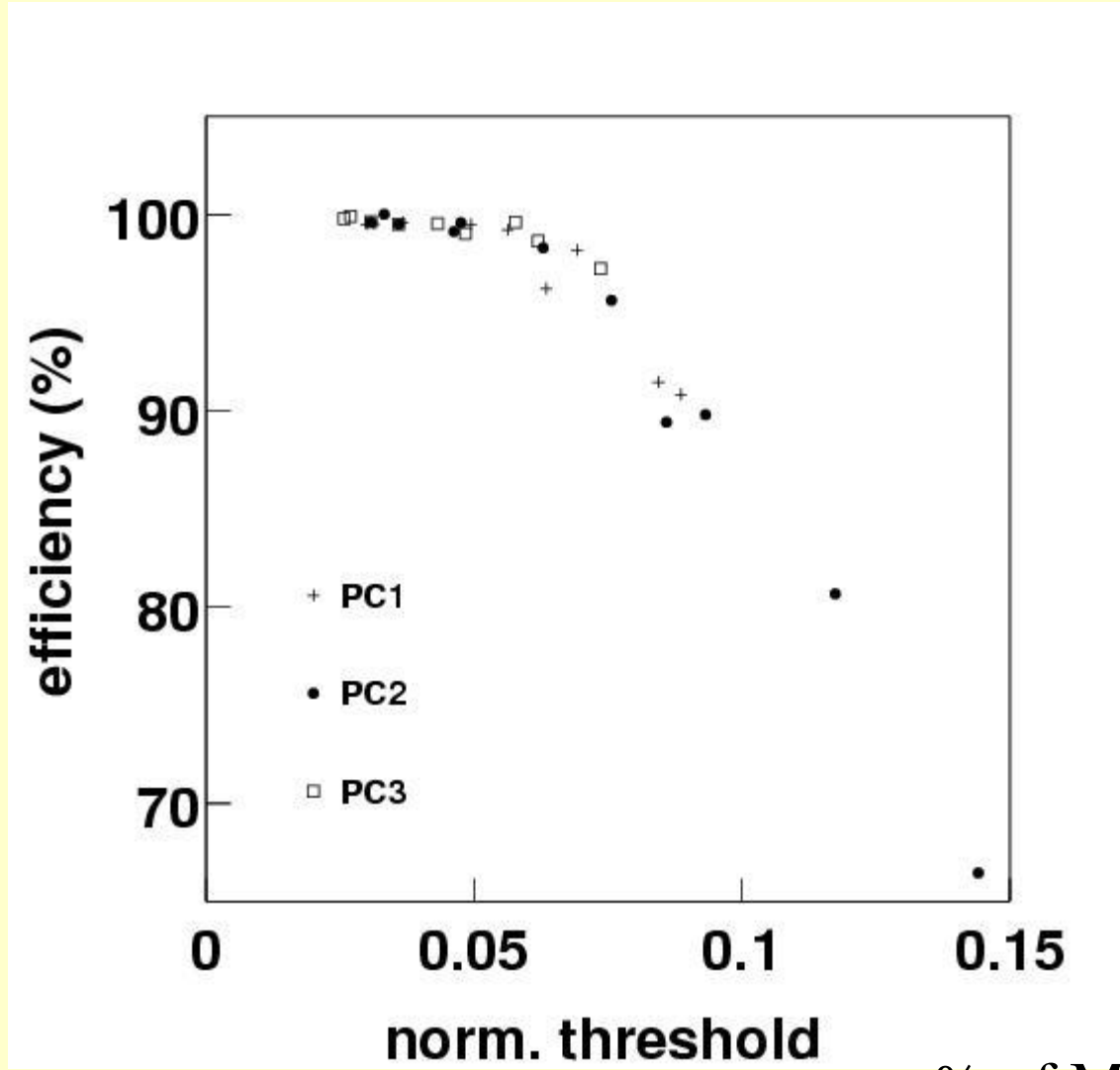


Performance: cosmics

efficiency

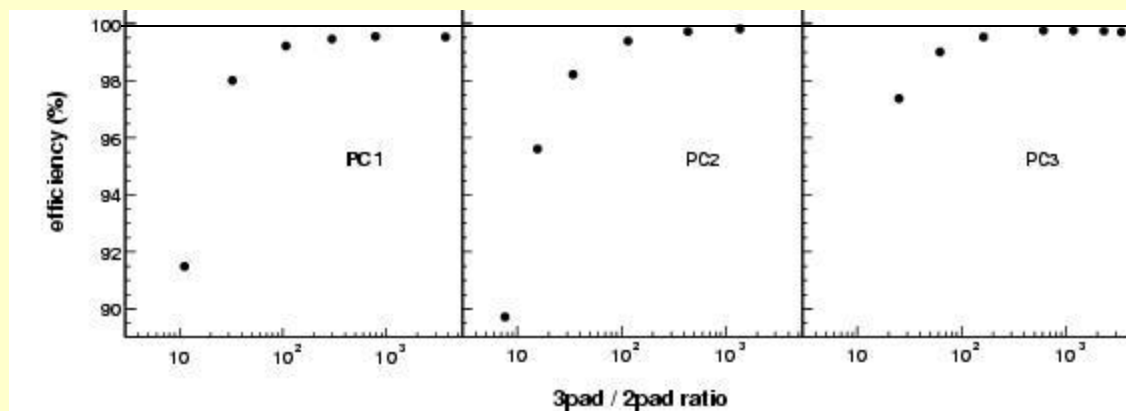
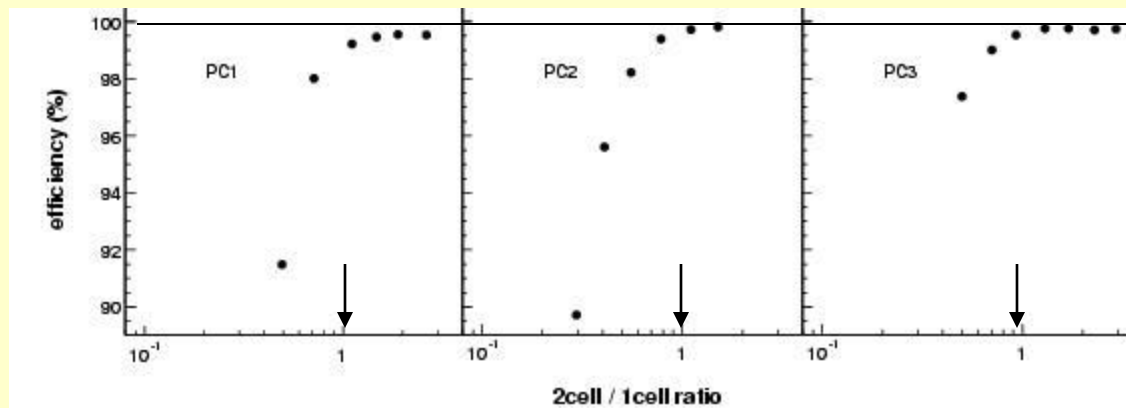


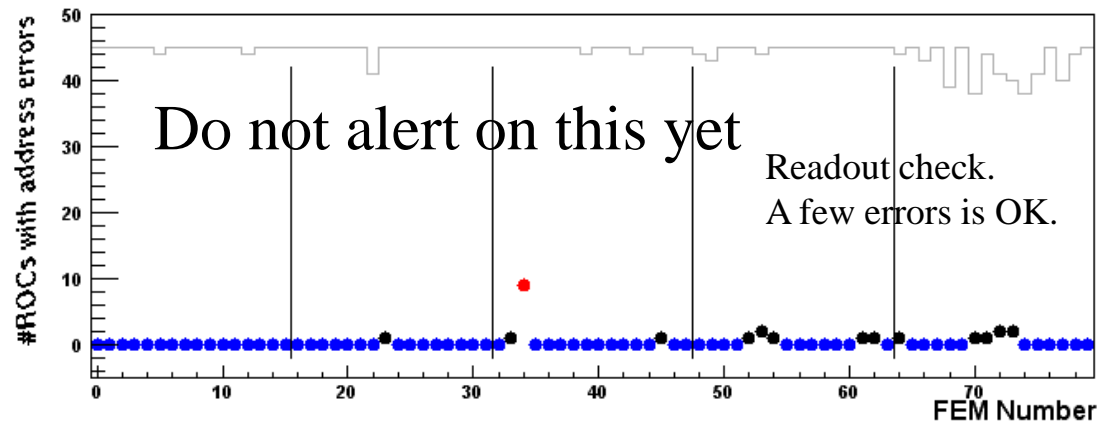
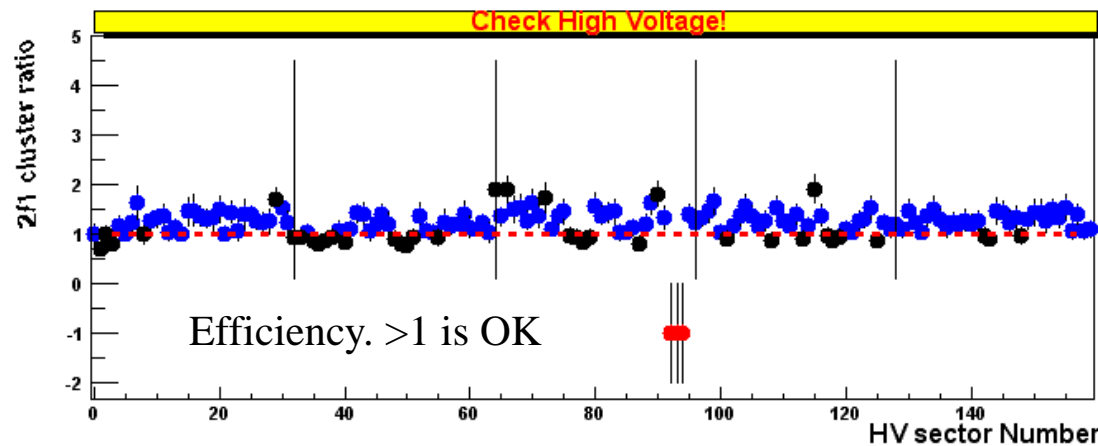
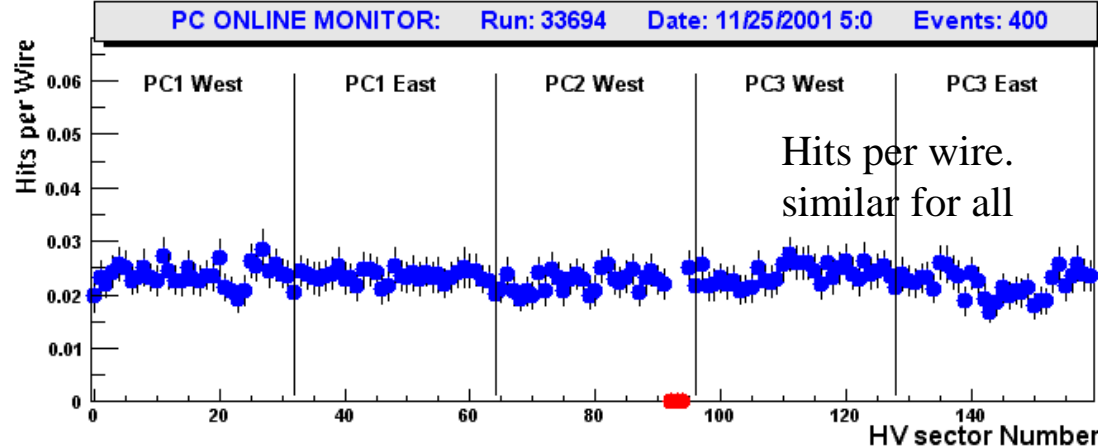
Performance: cosmics



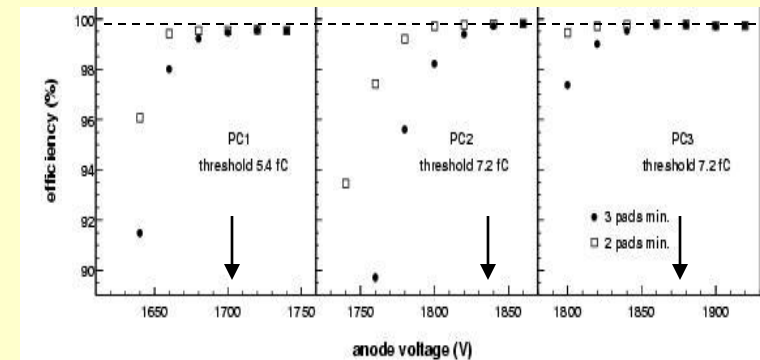
% of MIP peak

Performance: cosmics

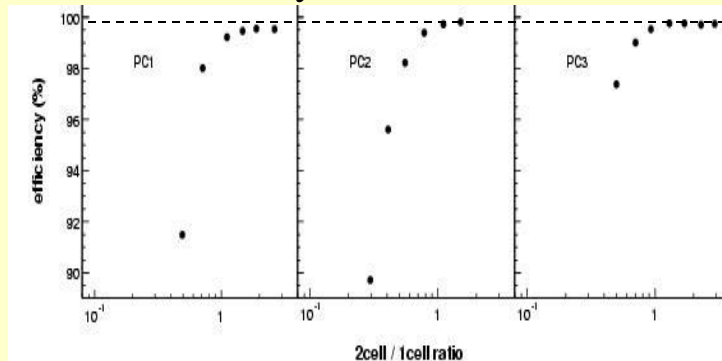




Efficiency vs HV



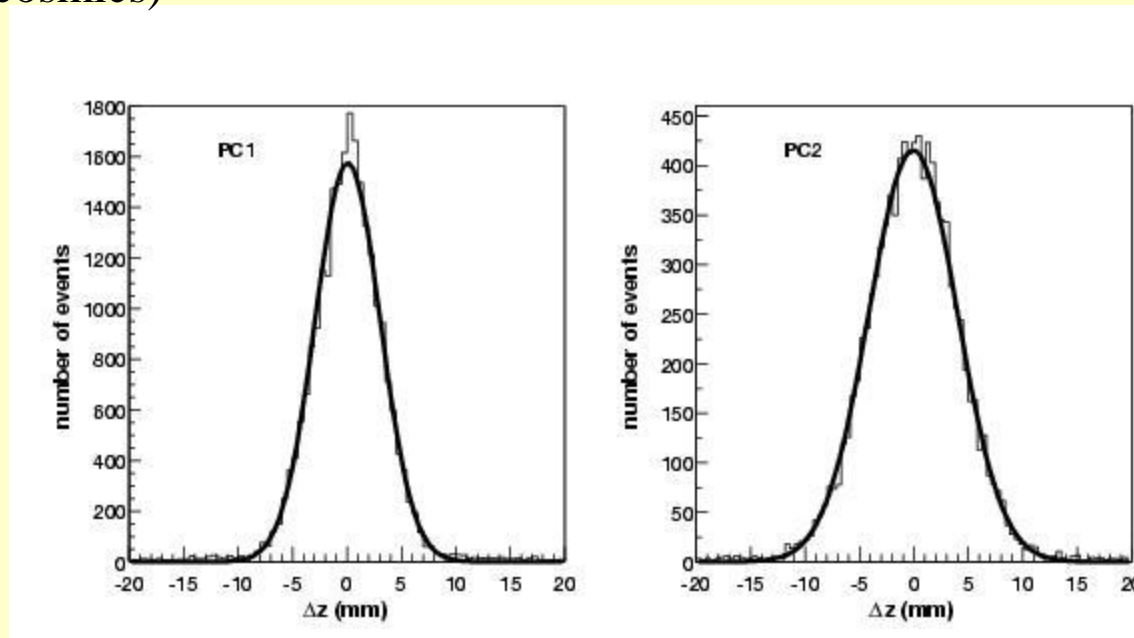
Efficiency vs monitor ratio



- If red, follow the instr.
- 1 Hv-sector is one channel
- 8 channels is one bulk supply
- Most trips are: 1 or 8 channels
- Readout check is under eval.
- Wait for enough statistics.

Position resolution in Z

(cosmics)



measured

chamber	Wire dist (mm)	Z-resol. (mm)	Perp res (mm)	Rad. Thickn.
PC1	8.4	1.7	2.5	1.2%
PC2	13.6	3.1	3.9	2.4%
PC3	16.0	3.6	4.6	2.4%

PHENIX

Chamber information

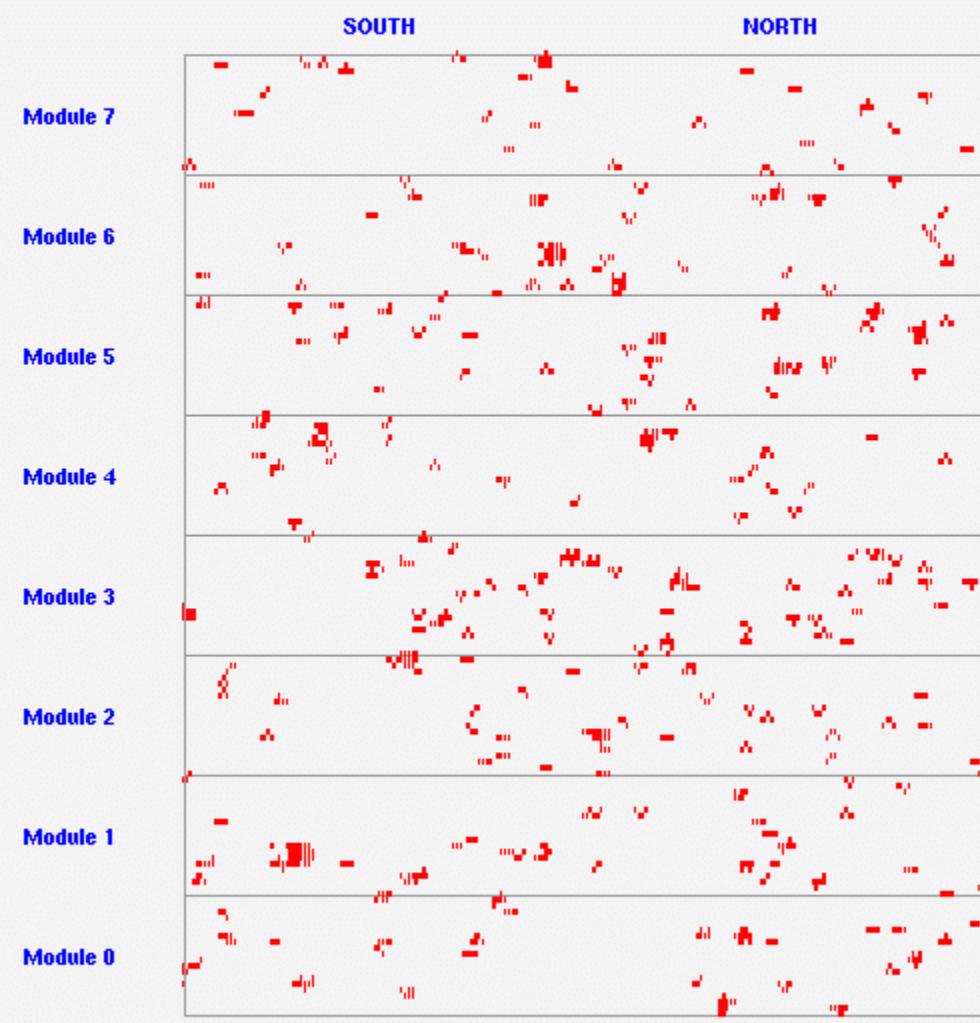
Chamber : PC1
 Arm : WEST
 Side : SOUTH
 Module : 7
 Packet id : 4008
 Module addr. : 21d
 Fired : 1189
 Occupancy : 0.034404
 Row : 2
 ROC : 8
 RGL : 3
 Channel : 11
 Role : 22
 : 93
 Fire : 18
 Channel index : 1886

Online status

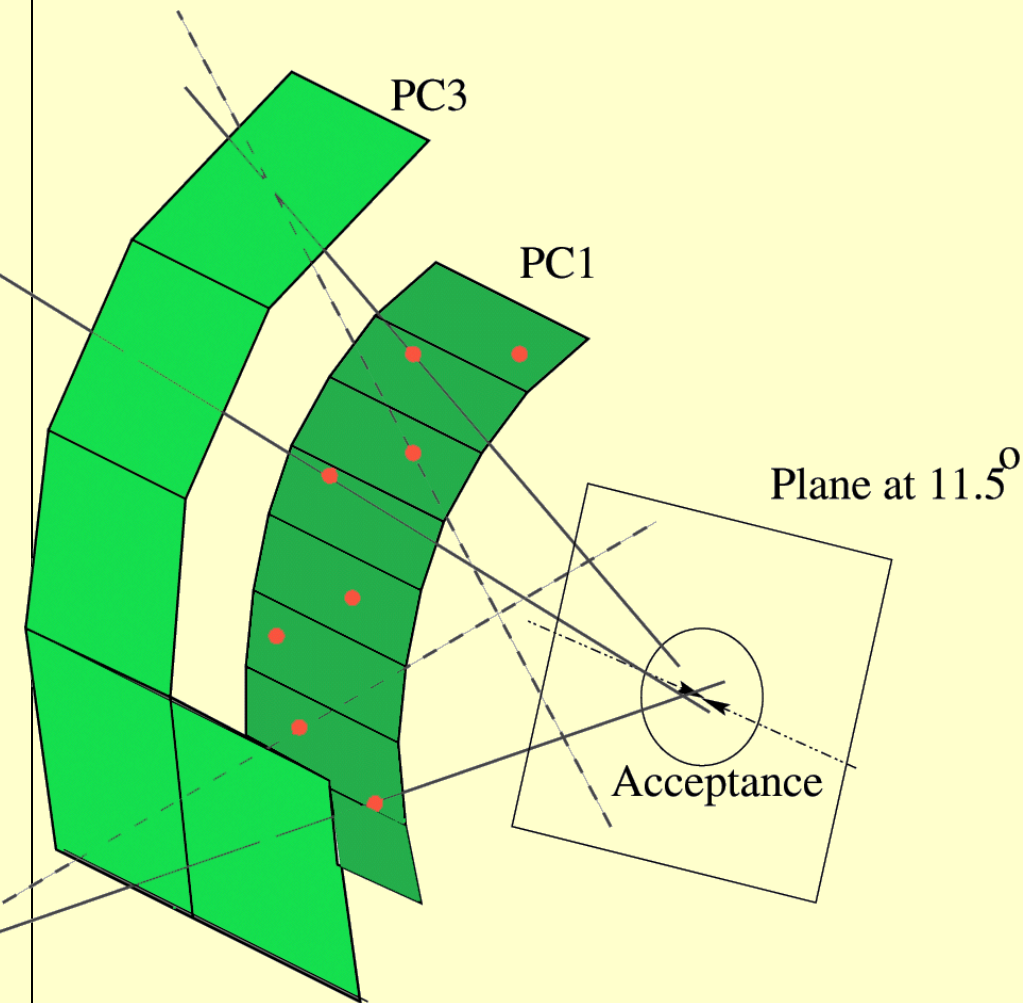
Event number : 13
 Number in set : 3
 Total in set : 5
 File name :
 0022826-0000.PRDF
 Draw mode : PADS
 View : PIXEL SIDE

Chamber | Mod 0 | Mod 1 | Mod 2 | Mod 3 | Mod 4 | Mod 5 | Mod 6 | Mod 7 | Rec. Pads | Rec. Cells

Performance Au+Au central



Hit Matching Procedure



The analysis presented here was performed with **field off** runs only and using PC1 and PC3 in the East arm. (For year-2: also West arm)

The background contribution is determined by a mixed event technique of exchanging each PC1 sector with its neighbour.

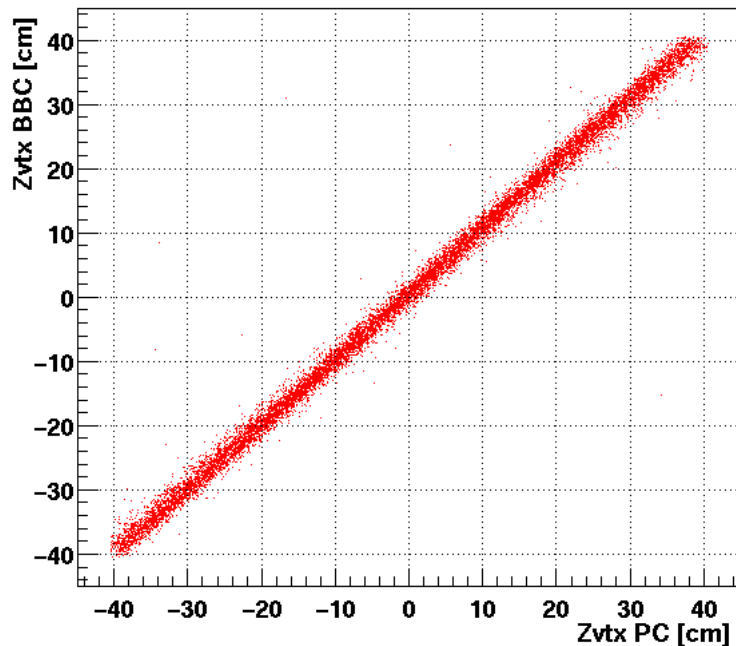
Vertex reconstruction is done by PC/BBC.

Vertex Reconstruction

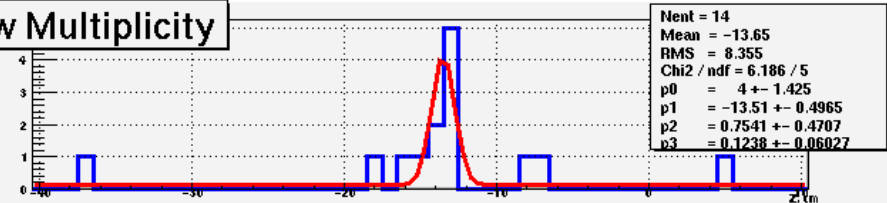
The vertex position is determined by

- 1) Combining all PC1 and PC3 hits to lines
- 2) Project the lines to the plane and save all within an appropriate X and Y window.
- 3) Calculate the peak position of the Z distribution.

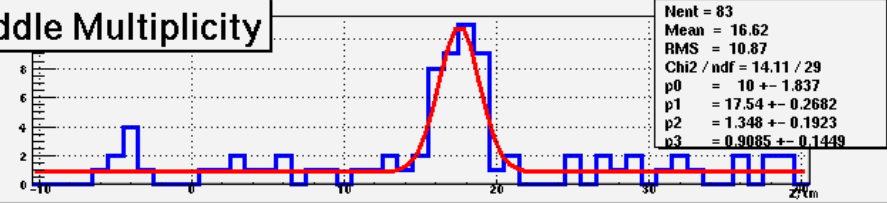
Vertex reconstructed by PC and BBC



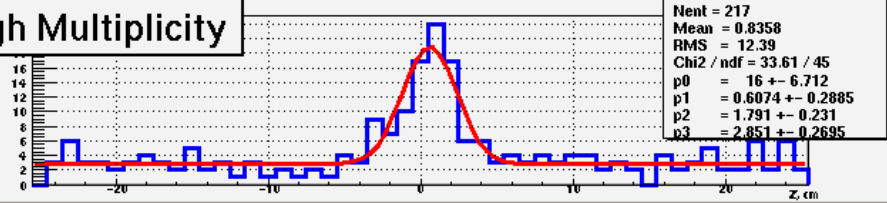
Low Multiplicity



Middle Multiplicity



High Multiplicity

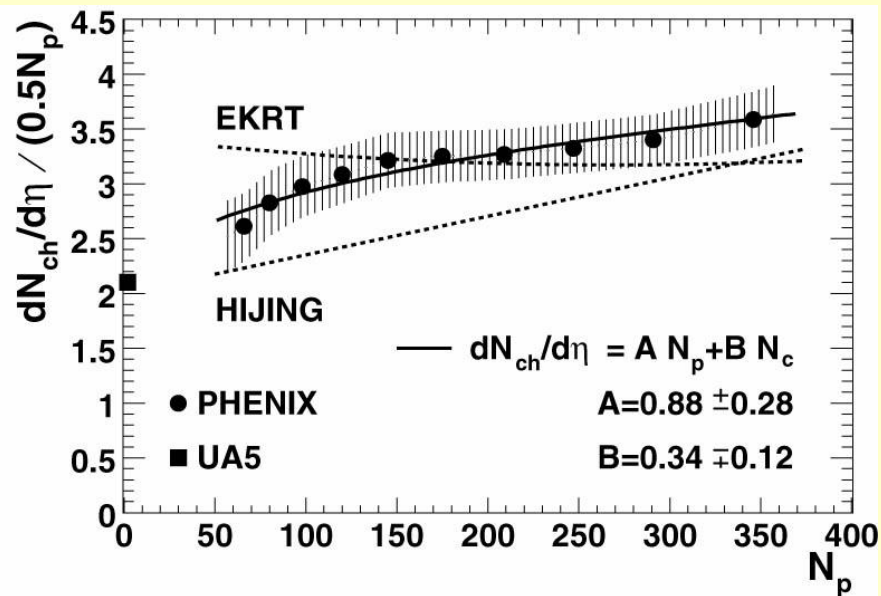
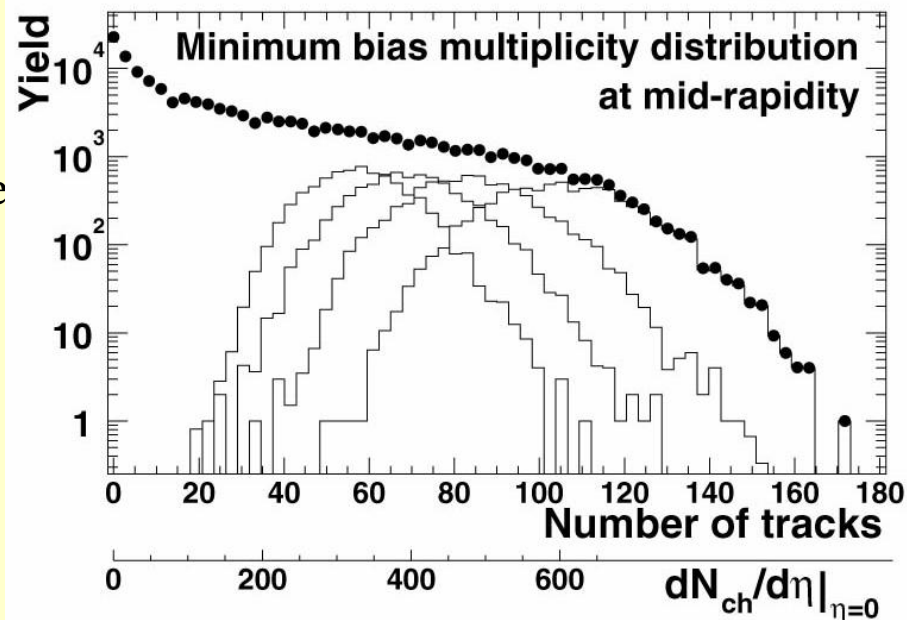


The vertices found by PC and BBC agree nicely. By repeating the procedure with a tighter cut placed around the found vertex, one can estimate the number of tracks in the collision.

Multiplicity distribution @ 130 GeV

Distribution has been scaled by the known correction factors, to correspond to a coverage of ± 0.5 in η and 2π in ϕ .

Width of high N_{ch} roll-off is a function of e.g. finite aperture.



First results on centrality dependence of charged particle multiplicity at RHIC energies.

If you never wanna see anything
more about them pad-chambers:

Avoid NIM A where this 50 page writeup
is coming soon at a library near you.

and

WWW/p/draft/andosk/pcnim/final/det_counc/nim_det_counc.ps

Construction and Performance of the PHENIX Pad
Chambers

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d+Au

Hits/event/plane

West arm,
Retracted

No tracking done
So some backgnd

ZDC trigg.
No vertex cut.

